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ACCESS TO SPACE STUDIES

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Introduction

The National Aeronautics and Space Administration is currently considering possible directions in Earth-to-orbit vehicle development under a study called "Access to Space." This agency-wide study is considering commercial launch vehicles, human transportation, space station logistics, and other space transportation requirements over the next 40 years. Three options are being considered for human transportation: continued use of the Space Shuttle, development of a small personnel carrier (personnel logistics system, PLS), or development of an advanced vehicle such as a single-stage-to-orbit (SSTO). Several studies related to the overall Access to Space study are reported in this document.

Hydrogen Upper Stage for Delta

The Delta commercial launch vehicle has had a long and successful life. One of the possibilities for extending the capability of the Delta is to replace the storable second stage and solid third stage with a hydrogen/oxygen stage. A study was conducted to show the payload potential of such a stage with several engine options. The first step in the study was executing the trajectory optimization program Opguid to find the burnout weight for each engine design point. The inert weight of the stage was calculated from weight estimating relationships developed for such a stage, and the payload was found by subtracting the inert weight from the burnout weight. Several propellant weight cases were computed for each engine case.

The RL10C, which has not been developed but is a derivative of an existing RL10 engine, was analyzed at several thrust levels and exit areas. The RL10A4, which is an existing engine, and an advanced expander were analyzed. A new engine concept called the Advanced Technology Low Cost engine (ATLC) under consideration for development was analyzed. It would have a low-pressure staged combustion cycle and an uncooled chamber. The results are shown in the enclosed figure. Because the thrust level of the RL10C could be chosen at the optimum value for this application, it provided a somewhat better payload than the other candidate engines.

The results of this study indicate that a hydrogen upper stage can provide a payload increase from 4010 lb, the capability of the existing Delta, to about 5600 lb.

The inert weight calculations used in the analysis assume a stage with self-supporting tanks with convex bulkheads. The inert weight is approximately 6500 lb. An existing stage, Centaur, has pressure-stabilized tanks and a concave lower hydrogen tank bulkhead. With these features, it has an inert weight of about 4300 lb. Using such a stage would increase the payload to about 6800 lb, but the costs may be greater.

Advanced SSTO Engines

A current contract with Rocketdyne is considering advanced hydrogen engines for the SSTO vehicle option. After considering previous engine studies for SSTO vehicles, several engine designs were selected for analysis. This analysis will include engine calculations by Rocketdyne and vehicle analysis by NASA. Vehicle calculations at The University of Alabama may also be included. The engines will include full-flow staged-combustion engines, hybrid expander engines, and SSME-type engines. Mixture ratios of 6 and 7 will be included. Initial results indicate that the full-flow engine can reduce the vehicle dry mass from 232,000 lb to 159,000 lb.

Expendable Hydrogen Tank SSTO

The fully reusable SSTO being considered should have considerably lower recurring costs than the Space Shuttle or PLS options. There has been an assumption that a fully reusable vehicle would have the lowest recurring costs. To explore this assumption, a concept has been studied with an expendable hydrogen tank. Initial vehicle results indicate that the vehicle gross weight drops from about 2.4 million lb for the fully reusable vehicle to under 1.8 million lb with the expendable hydrogen tank. This is because returning the hydrogen tank for reuse increases the size of the vehicle, increasing the thermal protection weight, the wings, landing gear, etc. The number of SSME's is reduced from 7 to 5. The development, production, spares, and engine costs are therefore reduced. This reduction is balanced by the added cost of the expended tank which must be replaced each flight. Cost estimates show that the net result is essentially no change in the total costs, but the early costs are reduced, which would provide a net savings if the time value of money is included in the analysis.

Orbiter instead of PLS

The PLS option studies have discovered a vehicle concept with some promise. It uses a reusable propulsion and avionics (PA) module with expendable tanks. Each PA module has two SSME's. With three PA modules, a 65,000 lb payload can be launched to the space station. Six flight of this cargo vehicle per year can provide the space station logistics. The PLS can be launched to the space station on the same vehicle. The recurring costs are estimated to be significantly lower

than the current Space Shuttle costs, but the development costs that must be invested to get to this system are quite high. In an attempt to reduce these costs, a concept was developed that does not require the PLS development. The Space Shuttle orbiter is used with a small oxygen tank in the payload bay and a small set of expendable hydrogen tanks. This orbiter and small tank set is launched with the vehicle with three PA modules. Weight estimates and trajectory results indicate that a 21,700 lb payload can be delivered to the space station.

Russian Engine PA Module

There is a possibility that Russian engines could be used in a new launch vehicle. The existing RD-170 engine has been proven to be reliable and has excellent performance. A concept was developed which would use a PA module to reuse one RD-170 and another PA module to reuse two SSME's. This concept would have more payload than the concept with three PA modules with two SSME's each, and the tank would be smaller because most of the fuel would be kerosene rather than hydrogen. One alternative to this concept is to use two RD-180 engines, each in a PA module, instead of one RD-170. The two SSME's would still be used. The RD-180 is essentially half of an RD-170. Another alternative is to use three PA modules, each with one RD-701 engine. The RD-701 is a tripropellant derivative of the RD-170. In this alternative, no SSME's would be needed.

Engine Comparisons

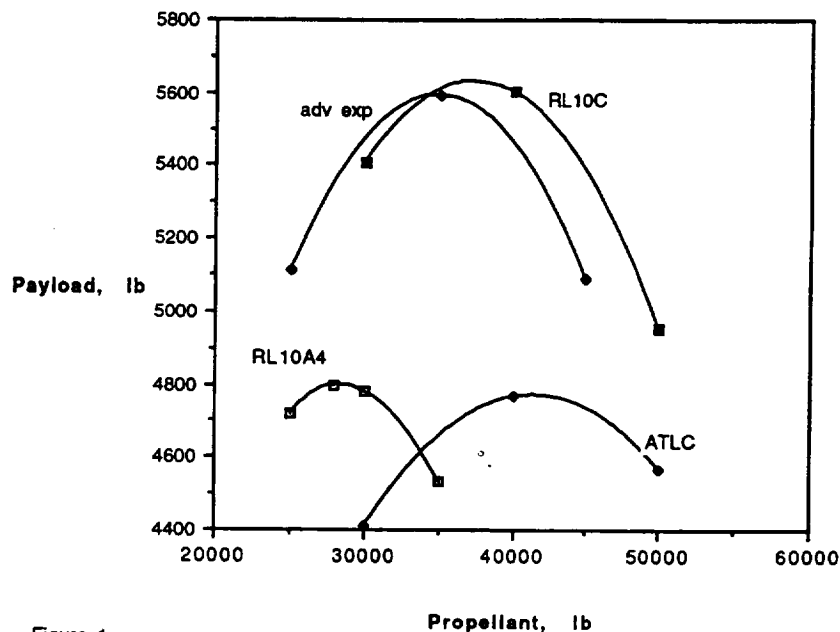


Figure 1

